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August 10, 2011

Charles R. Hoppin, Board Chairman
California State Water Resources
Control Board
Post Office Box 100
Sacramento, California 95812-0100

Subject: Clarification of Stanislaus River Fall-run Chinook Salmon Escapement Estimates

Dear Chairman Hoppin:

At the State Water Resources Control Board's June 6, 2011 Revised Notice of Preparation and Notice of Additional Scoping Meeting, the issue arose regarding accuracy of the Department of Fish and Game's (CDFG) fall-run Chinook salmon escapement estimates for the Stanislaus River. As you are aware, since 2003 there have been two counting methods employed in the Stanislaus River to estimate escapement of fall-run Chinook salmon. These two field methods are 1) traditional spawner (carcass) surveys and 2) weir counts. The following table provides a comparison between these two methods.

**Table 1. Stanislaus River Fall-run Chinook Salmon Escapement Estimates.**

| Year | Carcass Counts[1] | Weir Counts[2] |
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| 2003 | 5,902 | 4,832 |
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| 2008 | 1,392 | 923 |
| 2009 | 597 | 1,256 |
| 2010 | 1,086 | 1,377 |
| **Average** | **2,349** | **2,543** |

[1]Escapement estimates from California Department of Fish and Game, La Grange Field Office, include survey efforts through December 31st of each year.
[2]Weir count data from both Cramer Fish Sciences and FishBio reflect fall-run Chinook salmon counts through December 31st of each year.

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A formal statistical evaluation was conducted to determine if the escapement estimates, generated by these two estimation methods, are statistically different. The report is attached. In summary, the statistical evaluation, which used three separate analytical methods, concluded there is, at this time, no statistically significant difference (P>0.05) between the estimates generated by these two estimation field methods. However, given the limited number of years for comparison, caution is urged with respect to inference of results (e.g., with only eight years of data, the findings could change substantially if, and when, more years of data become available). Nonetheless, the management implication at this time is that there is not a statistically significant difference between these two field methods, thus CDFG's escapement estimates have NOT been proven wrong by weir counts, and can be reliably applied for Stanislaus River fall-run Chinook salmon fishery management.

For questions regarding this topic please contact Dean Marston, Environmental Program Manager, at 559-243-4014, extension 241, or at the address provided above.

Sincerely,

Andrew G. Gordus, Ph.D.

for Jeffrey R. Single, Ph.D.
Regional Manager

Attachment

cc: Frances Spivy-Weber
Tam M. Doduc
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California State Water Resources Control Board
Post Office Box 100
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Dean Marston
Department of Fish and Game

# Stanislaus Fall-run Chinook Salmon (Oncorhynchus tshawytscha) Escapement Estimate Comparison

July 2011

Alan Hubbard
Professor BioStatistics
University at California Berkeley

Tatiana Gabor
Statistician
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## Introduction

Since 2003, two methods have been employed to estimate numbers of fall-run Chinook salmon escaping to the Stanislaus River to spawn. These two methods are i) traditional spawner counts (aka: carcass surveys) conducted by the California Department of Fish and Game (Department) and ii) weir counts conducted by consultants[1] and funded by[2] local irrigation districts. These two methods collected data independent of one another and processing of collected data was not interconnected. The weir count method was employed because there was concern that the Department's traditional spawner count estimates were not accurate. The objective of this analysis is to compare the estimates generated by these two methods using statistical methodology.

## Methods/Results

Three approaches were used to compare Carcass and Weir counting methods: i) linear regression, ii) paired t-test, and iii) Wilcoxon sign test. These approaches and the results are presented below. The data that were used for this analysis are provided in the following table.

**Table 1. Stanislaus Fall-run Chinook Salmon Escapement Estimates.**

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### Linear Regression

To assess relationship between these two estimation methods we evaluate the linear association between the estimates produced by each method. For purposes of this assessment, Y1 = Weir Estimates and Y2 = Carcass Survey Estimates. It is noted that the Y1 and Y2 variables are interchangeable for this analysis (e.g. Weir Estimates could be Y2 and the results of this analysis would not change). In linear

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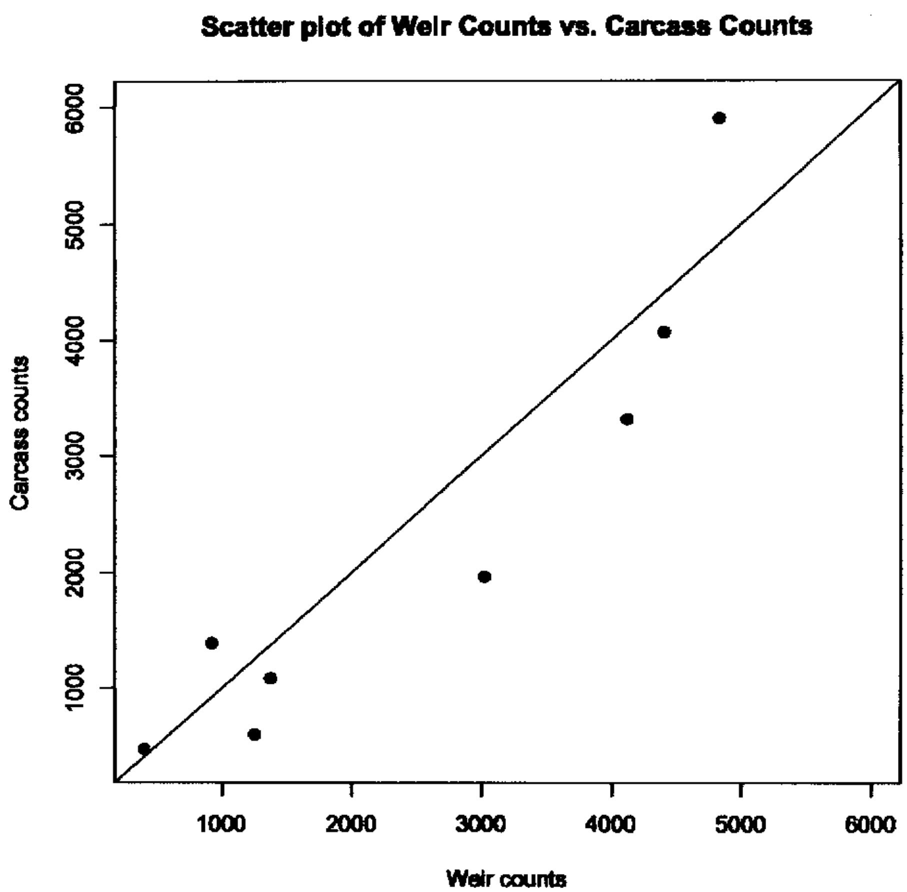
regression, Y1 = intercept + slope * Y2. We estimate slope by calculating a linear regression line from the data in Table 1. The closer the slope is to one, the closer the two methods go together. If a slope equals one then for each unit change in Y2, Y1 would also change by one unit. Furthermore, R-squared, which in this case is just a square of the correlation between Y1 and Y2, is an indicator of goodness of fit, with one being the perfect fit between the estimates produced by both methods. Below are 95% confidence intervals for slope and R-squared.

The 95% confidence interval range for slope is from 0.517 to 1.188

The 95% confidence interval range for R-squared is from 0.754 to 0.977

Scatter plot depicted in Figure 1 reflects positive linear relationship between counts produced by two methods.

**Figure 1.** Scatter plot of juvenile salmon Carcass counts versus Weir counts with an overlaid line with slope of 1 and intercept at the origin.



We can also test whether the slope is significantly different from one. The Null hypothesis ($H_0$) for this assessment is that the slope is equal to one. The Alternative hypothesis ($H_1$) for this analysis is that the slope does not equal one.

The results of the linear regression test:

Ho: slope = 1
Ha: slope != 0
Test statistic t = -1.058
P-value is 0.331

Conclusions: i) confidence intervals show that both slope and R-squared are relatively high, indicating close fit between the estimates produced by the two methods; ii) in the test for slope, there is not enough evidence to reject null (P value >0.05), therefore, the slope is not statistically different from one.

**Paired t-test**

The paired t-test tests whether two methods produce the same mean counts. The Null hypothesis ($H_0$) for the paired t-test is that the mean counts for each method are equal. The Alternative hypothesis is that the two methods produce different means. The means for the Weir count (Method 1) and Carcass survey (Method 2) methods are 2,543 and 2,349 respectively. The observed difference is equal to sample mean Method 1 – sample mean Method 2, which equals -193.375. If the observed difference between the means of the two methods is large enough, we reject the null hypothesis in favor of the alternative hypothesis. The t-test statistic helps determine if this difference is large enough.

The results of the paired t-test:

Ho: mean of Weir counts- Carcass counts = 0
Ha: mean of Weir counts- Carcass count != 0
Test statistic t= -0.7765
P-value = 0.4629

Conclusions: The P-value is greater than 0.05: therefore, we cannot reject the null hypothesis, meaning that the two methods have equal means (and thus the data is consistent with the model, $Y1 = Y2+e$, $E(e/Y2)=0$). Note that this paired t-test is equivalent then to a joint test of the intercept=0, slope=1 in the linear regression above. In summary, even though the means for the two methods differ by 193, the difference is not significant, and consistent with chance variation.

**Sign Test**

This test is an exact, non-parametric alternative to the paired t-test. The sign test evaluates the Null hypothesis that the median counts produced by two methods are equal against the Alternative that they are not.

The results of the sign test:

| sign | observed | expected |
|---|---|---|
| positive | 5 | 4 |
| negative | 3 | 4 |
| zero | 0 | 0 |
| all | 8 | 8 |

Ho: median of Weir counts – Carcass counts = 0
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Pr(#positive ≥ 5 or #negative >= 5) = min(1, 2*Binomial(n = 8, x ≥ 5, p =0.5))
= 0.7266

Thus, P-value is 0.7266

Conclusions: Again, the P-value is a lot higher than the rejection threshold of 0.05. Therefore, median difference between estimates produced by the two methods is not significantly different from zero, so observed difference is due to chance variation. It can be concluded that no one method consistently over predicts or under predicts compared to the other method.

Discussion

The inference derived from the statistical evaluations comparing the estimation differences between these two methods must be considered with caution due to there being few (8) data points. Nonetheless, at this point in time given the data set currently available, the escapement estimates for each method are not significantly different from one another (i.e. one method is not statistically different than the other). More importantly, given the small sample available, the mean difference is small, and the estimated R-squared large, suggesting that the best information is that the two methods provide similar estimates on a year by year basis.

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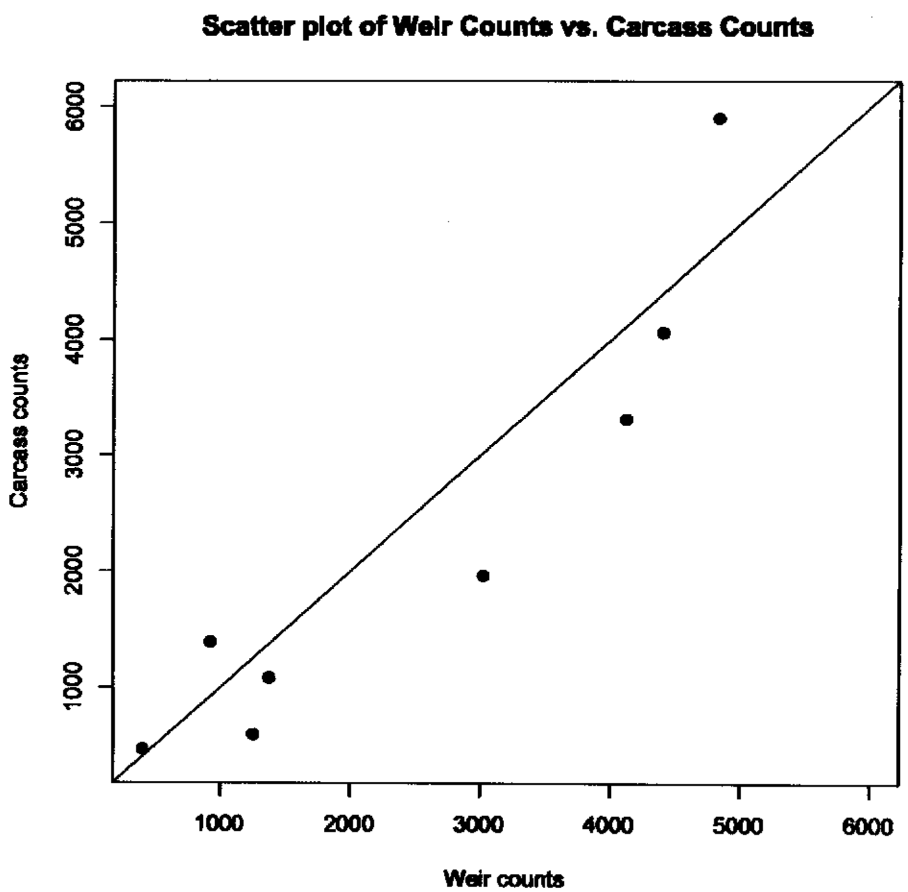

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